CLAIMS

What is claimed is:

1. (Currently amended) An electroplating bath for depositing a zinc-nickel ternary or higher alloy, comprising:

a) zinc ions, wherein the zinc ions are present in the bath as one or more of ZnO, $Zn(OH)_2$, $Zn(Cl)_2$, $ZnSO_4$, $ZnCO_3$, $Zn(SO_3NH_2)_2$, $Zn(OOCCH_3)_2$, $Zn(BF_4)_2$ and zinc methane sulfonate;

b) nickel ions, wherein the nickel ions are present in the bath as one or more of $NiSO_4$, $NiSO_4 \cdot 6H_2O$, $NiCO_3$, $Ni(SO_3NH_2)_2$, $Ni(OOCCH_3)_2$, $(NH_2)_2Ni(SO_4)_2$, Ni(OOCH)$_2$, a Ni complex, $Ni(BF_4)_2$ and nickel methane sulfonate;

c) from about 0.01 g/dm^3 to about 10 g/dm^3 of one or more ionic species selected from ions of Te^{+4}, Bi^{+3} and Sb^{+3}, with the proviso that when the ionic species comprises Te^{+4}, the bath further comprises one or more additional ionic species selected from ions of Bi^{+3}, Sb^{+3}, Ag^{+1}, Cd^{+2}, Co^{+2}, Cr^{+3}, Cu^{+2}, Fe^{+2}, In^{+3}, Mn^{+2}, Mo^{+6}, P^{+3}, Sn^{+2} and W^{+6}; and

d) one or more non-ionogenic surface active polyoxyalkylene compound, and further comprising ethylenediamine or its methyl-substituted derivatives; propylenediamine or its methyl-substituted derivatives; diethylenetriamine or its methyl-substituted derivatives; or a polymer of an aliphatic amine.

2. (Original) The bath of claim 1 wherein when the ionic species comprises one or more of Bi^{+3} or Sb^{+3}, the bath further comprises one or more additional ionic species selected from ions of Ag^{+1}, Cd^{+2}, Co^{+2}, Cr^{+3}, Cu^{+2}, Fe^{+2}, In^{+3}, Mn^{+2}, Mo^{+6}, P^{+3}, Sn^{+2} and W^{+6}.

3. (Currently amended) The bath of claim 1 wherein the zinc ~~ion~~ ions and the nickel ~~ion~~ ions are present in the bath at concentrations sufficient to deposit the alloy ~~comprising~~ , wherein the alloy comprises a nickel content from about 3 wt% to about 25 wt% of the alloy.

4. (Currently amended) The bath of claim 1 wherein the zinc ~~ion~~ ions and the nickel ~~ion~~ ions are present in the bath at concentrations sufficient to deposit the alloy ~~comprising~~ , wherein the alloy comprises a nickel content from about 8 wt% to about 22 wt% of the alloy.

5. (Previously presented) The bath of claim 1 wherein the concentration of Bi^{+3} is in the range from 0.2 to 2 g/dm^3.

6. (Currently amended) The bath of claim 1 wherein the one or more non-ionogenic surface active polyoxyalkylene compound comprises:

(i) at least one compound having a formula:

$$R^1\text{--}O\text{--}[(CH_2)_nO]_x\ H \qquad \text{(Ia)}$$

or

$$R^1\text{--}O\text{--}[(CHR^2CH_2)O]_x\ H \qquad \text{(Ib)}$$

or

$$R^1\text{--}O\text{--}[(CH_2CHR^2)O]_x\ H \qquad \text{(Ic)}$$

wherein R^1 is an aryl or alkyl group containing up to about 24 carbon atoms, R^2 is an alkyl group containing from 1 to about 4 carbon atoms, n is 2 or 3, and x is an integer between 2 and about 100;

(ii) at least one compound having a formula:

$$R^3\text{-}O\text{-}[R^4\text{-}O\text{-}]_n\text{-}X \qquad \text{(IIa)}$$

or

$$(R^3\text{-}O\text{-}[R^4\text{-}O\text{-}]_n)_a\text{-}Y \qquad \text{(IIb)}$$

wherein R^3 = a C_1-C_{18} branched or unbranched alkyl, alkylene or alkynyl group, or phenyl-O-$[R^5$-O-$]_m$-CH_2-, in which m = 0-100, n is 2 or 3 and R^5 is a C_1-C_4 branched or unbranched alkylene; R^4 = a C_1-C_4 branched or unbranched alkylene; X = H, -NH_2, -Cl, -Br, -SO_2Z, -SO_3Z, -SO_4Z, -PO_3Z_2, or -PO_4Z_2 , wherein Z independently ~~may be~~ is one or more of H, an alkali metal ion, ~~or may be~~ and Z_2 is optionally an alkaline earth

metal ion, ~~$-NH_2$, -Cl or -Br~~; Y is an aliphatic polyhydroxy group, an amine group, a polyamine group or a mercaptan group, and a is equal to or less than the number of active hydrogens in OH, -NH, NH_2 or -SH groups on the Y component; or

(iii) a mixture of two or more of (i) and/or (ii).

7. (Original) The bath of claim 1 wherein the bath comprises an acidic pH.

8. (Previously presented) The bath of claim 1 wherein the bath comprises an alkaline pH.

9. (Previously presented) The bath of claim 1 wherein the concentration of Sb^{+3} is in the range from 0.1 to 3 g/dm^3.

10. (Previously presented) The bath of claim 8 further comprising a compound represented by the formula

$$R^7(R^8)N-R^{11}-N(R^9)R^{10} \qquad (V)$$

wherein R^7, R^8, R^9 and R^{10} are each independently alkyl or hydroxyalkyl groups provided that one or more of R^7 -R^{10} is a hydroxy alkyl group, and R^{11} is a hydrocarbylene group containing up to about 10 carbon atoms, or a mixture of two or more thereof.

11-42. (Cancelled)

43. (Currently amended) An electroplating bath for depositing a zinc-nickel ternary or higher alloy, comprising:

a) zinc ions, wherein the zinc ions are present in the bath as one or more of ZnO, $Zn(OH)_2$, $Zn(Cl)_2$, $ZnSO_4$, $ZnCO_3$, $Zn(SO_3NH_2)_2$, $Zn(OOCCH_3)_2$, $Zn(BF_4)_2$ and zinc methane sulfonate;

b) nickel ions, wherein the nickel ions are present in the bath as one or more of $NiSO_4$, $NiSO_4 \cdot 6H_2O$, $NiCO_3$, $Ni(SO_3NH_2)_2$, $Ni(OOCCH_3)_2$, $(NH_2)_2Ni(SO_4)_2$, $Ni(OOCH)_2$, a Ni complex, $Ni(BF_4)_2$ and nickel methane sulfonate;

c) from about 0.01 g/dm^3 to about 10 g/dm^3 of one or more ionic species selected from ions of Te^{+4}, Bi^{+3} and Sb^{+3}, and

d) one or more non-ionogenic surface active polyoxyalkylene compound, with the proviso that when the ionic species comprises Te^{+4}, the bath is free of a mixture of brighteners comprising both (i) reaction product of epihalohydrin with an alkylene amine, and (ii) aromatic aldehydes,

and further comprising ethylenediamine or its methyl-substituted derivatives; propylenediamine or its methyl-substituted derivatives; diethylenetriamine or its methyl-substituted derivatives; or a polymer of an aliphatic amine.

44. (Original) The bath of claim 43 wherein the bath further comprises one or more additional ionic species selected from ions of Ag^{+1}, Cd^{+2}, Co^{+2}, Cr^{+3}, Cu^{+2}, Fe^{+2}, In^{+3}, Mn^{+2}, Mo^{+6}, P^{+3}, Sn^{+2} and W^{+6}.

45. (Canceled)

46. (Currently amended) The bath of claim 43 wherein the zinc ~~ion~~ ions and the nickel ~~ion~~ ions are present in the bath at concentrations sufficient to deposit the alloy ~~comprising~~ , wherein the alloy comprises a nickel content from about 3 wt% to about 25 wt% of the alloy.

47. (Currently amended) The bath of claim 43 wherein the zinc ~~ion~~ ions and the nickel ~~ion~~ ions are present in the bath at concentrations sufficient to deposit the alloy ~~comprising~~ , wherein the alloy comprises a nickel content from about 8 wt% to about 22 wt% of the alloy.

48. (Previously presented) The bath of claim 43 wherein the concentration of Bi^{+3} is in the range from 0.2 to 2 g/dm^3.

49. (Previously presented) The bath of claim 43 wherein the concentration of Sb^{+3} is in the range from 0.1 to 3 g/dm^3.

50. (Currently amended) The bath of claim 43 wherein the one or more non-ionogenic surface active polyoxyalkylene compound comprises:

(i) at least one compound having a formula:

$$R^1\text{--}O\text{--}[(CH_2)_nO]_x\,H \qquad \text{(Ia)}$$

or

$$R^1\text{--}O\text{--}[(CHR^2CH_2)O]_x\,H \qquad \text{(Ib)}$$

or

$$R^1\text{--}O\text{--}[(CH_2CHR^2)O]_x\,H \qquad \text{(Ic)}$$

wherein R^1 is an aryl or alkyl group containing up to about 24 carbon atoms, R^2 is an alkyl group containing from 1 to about 4 carbon atoms, n is 2 or 3, and x is an integer between 2 and about 100;

(ii) at least one compound having a formula:

$$R^3\text{-}O\text{-}[R^4\text{-}O\text{-}]_n\text{-}X \qquad \text{(IIa)}$$

or

$$(R^3\text{-}O\text{-}[R^4\text{-}O\text{-}]_n)_a\text{-}Y \qquad \text{(IIb)}$$

wherein R^3 = a C_1-C_{18} branched or unbranched alkyl, alkylene or alkynyl group, or phenyl-O-$[R^5$-O-$]_m$-CH_2-, in which m = 0-100, n is 2 or 3 and R^5 is a C_1-C_4 branched or unbranched alkylene; R^4 = C_1-C_4 branched or unbranched alkylene; X = H, <u>-NH_2, -Cl, -Br,</u> -SO_2Z, -SO_3Z, -SO_4Z, -PO_3Z_2, <u>or</u> -PO_4Z_2 , wherein Z independently ~~may be~~ <u>is one or more of</u> H, an alkali metal ion, ~~or may be~~ <u>and</u> Z_2 <u>is optionally</u> an alkaline earth metal ion, ~~-NH_2, -Cl or -Br~~; Y is an aliphatic polyhydroxy group, an amine group, a polyamine group or a mercaptan group, and a is equal to or less than the number of active hydrogens in OH, -NH, NH_2 or -SH groups on the Y component; or

(iii) a mixture of two or more of (i) and/or (ii).

51. (Previously presented) The bath of claim 43 wherein the bath comprises an acidic pH.

52. (Previously presented) The bath of claim 43 wherein the bath comprises an alkaline pH.

53. (Previously presented) The bath of claim 52 further comprising a compound represented by the formula

$$R^7(R^8)N-R^{11}-N(R^9)R^{10} \qquad (V)$$

wherein R^7, R^8, R^9 and R^{10} are each independently alkyl or hydroxyalkyl groups provided that one or more of R^7 -R^{10} is a hydroxy alkyl group, and R^{11} is a hydrocarbylene group containing up to about 10 carbon atoms, or a mixture of two or more thereof.

54. (Canceled)

55. (Currently amended) An electroplating bath for depositing a zinc-nickel quaternary or higher alloy, comprising:

a) zinc ions, wherein the zinc ions are present in the bath as one or more of ZnO, $Zn(OH)_2$, $Zn(Cl)_2$, $ZnSO_4$, $ZnCO_3$, $Zn(SO_3NH_2)_2$, $Zn(OOCCH_3)_2$, $Zn(BF_4)_2$ and zinc methane sulfonate;

b) nickel ions, wherein the nickel ions are present in the bath as one or more of $NiSO_4$, $NiSO_4 \cdot 6H_2O$, $NiCO_3$, $Ni(SO_3NH_2)_2$, $Ni(OOCCH_3)_2$, $(NH_2)_2Ni(SO_4)_2$, $Ni(OOCH)_2$, a Ni complex, $Ni(BF_4)_2$ and nickel methane sulfonate;

c) one or more ionic species selected from ions of Te^{+4}, Bi^{+3} and Sb^{+3};

d) one or more ionic species selected from ions of Ag^{+1}, Cd^{+2}, Co^{+2}, Cr^{+3}, Cu^{+2}, Fe^{+2}, In^{+3}, Mn^{+2}, Mo^{+6}, P^{+3}, Sn^{+2} and W^{+6}; and

e) one or more non-ionogenic surface active polyoxyalkylene compound,

and further comprising ethylenediamine or its methyl-substituted derivatives; propylenediamine or its methyl-substituted derivatives; diethylenetriamine or its methyl-substituted derivatives; or a polymer of an aliphatic amine.

56. (Currently amended) The bath of claim 55 wherein the zinc ~~ion~~ ions and the nickel ~~ion~~ ions are present in the bath at concentrations sufficient to deposit the alloy ~~comprising~~ , wherein the alloy comprises a nickel content from about 3 wt% to about 25 wt% of the alloy.

57. (Currently amended) The bath of claim 55 wherein the zinc ~~ion~~ ions and the nickel ~~ion~~ ions are present in the bath at concentrations sufficient to deposit the alloy ~~comprising~~ , wherein the alloy comprises a nickel content from about 8 wt% to about 22 wt% of the alloy.

58. (Previously presented) The bath of claim 55 wherein the concentration of Bi^{+3} is in the range from 0.2 to 2 g/dm^3.

59. (Previously presented) The bath of claim 55 wherein the concentration of Sb^{+3} is in the range from 0.1 to 3 g/dm^3.

60. (Currently amended) The bath of claim 55 wherein the one or more non-ionogenic surface active polyoxyalkylene compound comprises:

(i) at least one compound having a formula:

$$R^1\text{--}O\text{--}[(CH_2)_nO]_x\,H \qquad \text{(Ia)}$$

or

$$R^1\text{--}O\text{--}[(CHR^2CH_2)O]_x\,H \qquad \text{(Ib)}$$

or

$$R^1\text{--}O\text{--}[(CH_2CHR^2)O]_x\,H \qquad \text{(Ic)}$$

wherein R^1 is an aryl or alkyl group containing up to about 24 carbon atoms, R^2 is an alkyl group containing from 1 to about 4 carbon atoms, n is 2 or 3, and x is an integer between 2 and about 100;

(ii) at least one compound having a formula:

$$R^3\text{-}O\text{-}[R^4\text{-}O\text{-}]_n\text{-}X \qquad \text{(IIa)}$$

or

$$(R^3\text{-}O\text{-}[R^4\text{-}O\text{-}]_n)_a\text{-}Y \qquad \text{(IIb)}$$

wherein R^3 = a C_1-C_{18} branched or unbranched alkyl, alkylene or alkynyl group, or phenyl-O-$[R^5\text{-}O\text{-}]_m\text{-}CH_2$-, in which m = 0-100, n is 2 or 3 and R^5 is a C_1-C_4 branched or unbranched alkylene; R^4 = C_1-C_4 branched or unbranched alkylene; X = H, -NH_2, -Cl, -Br, -SO_2Z, -SO_3Z, -SO_4Z, -PO_3Z_2, or -PO_4Z_2 , wherein Z independently ~~may be~~ is one or more of H, an alkali metal ion, ~~or may be~~ and Z_2 is optionally an alkaline earth metal ion, ~~-NH_2, -Cl or -Br~~; Y is an aliphatic polyhydroxy group, an amine group, a polyamine group or a mercaptan group, and a is equal to or less than the number of active hydrogens in OH, -NH, NH_2 or -SH groups on the Y component; or

(iii) a mixture of two or more of (i) and/or (ii).

61. (Previously presented) The bath of claim 55 wherein the bath comprises an acidic pH.

62. (Previously presented) The bath of claim 55 wherein the bath comprises an alkaline pH.

63. (Previously presented) The bath of claim 62 further comprising a compound represented by the formula

$$R^7(R^8)N\text{-}R^{11}\text{-}N(R^9)R^{10} \qquad \text{(V)}$$

wherein R^7, R^8, R^9 and R^{10} are each independently alkyl or hydroxyalkyl groups provided that one or more of R^7 -R^{10} is a hydroxy alkyl group, and R^{11} is a

hydrocarbylene group containing up to about 10 carbon atoms, or a mixture of two or more thereof.

64. (Canceled)